

Improvements to Angle Data System Autocollimators

R. A. Zanteson
DSIF Engineering Section

The Angle Data System of the 64-m-diameter antenna utilizes two-axis autocollimators as the optical link between the precision instrument mount and the intermediate reference optical assembly. The accuracy, resolution and stability of these instruments directly affects the pointing accuracy of the antennas. With an accuracy and resolution of better than one arc second, great care must be taken in each phase of the design and construction.

The Angle Data System of the 64-m-diameter antenna utilizes two-axis automatic autocollimators as the optical link between the precision instrument mount, located at the intersection of the antenna axis, and the intermediate reference optical assembly.

The autocollimators currently in use at DSS 14 represent the state of the art at the time of their purchase (1965). The trend toward higher operating frequencies of the 64-m subnet, with attendant narrower beamwidths, places an emphasis on the need for higher overall accuracy of the Angle Data System. In the procurement of the autocollimators for the overseas 64-m antennas, the work which has been done in order to meet these needs includes the areas of higher resolution, accuracy, and long-term stability. A simplified schematic of the new design is included as Fig. 1.

The autocollimators must maintain their full accuracy and null stability while moving through all attitudes, with respect to gravity. During the design, particular emphasis was placed on the structural rigidity of each component, both singly and as it relates to the entire assembly.

One source of attitude instability has been the tungsten filament lamp, which is the primary illumination source. In the previous design, a broad filament lamp was mounted in the autocollimator housing to illuminate the 0.94-millimeter square source stop, with a pair of unsymmetrical condensor lenses interposed to concentrate and diffuse the lamp filament image. The gravity deflection of the filament contributed five-arc second error. It was not practical to make the filament and its supports

sufficiently stiff to avoid degrading the uniformity of illumination across the source stop as they deflect due to gravity.

In the design of the new units, a more conventional lamp is used which satisfies the dual need for radiation in the visual spectrum, and a peak output compatible with the 900-nm peak of the silicon detector used in the primary system. This lamp is now housed separately from the optical sensing head. This basic change in design incorporates many advantages. The removal of the lamp as a heat source from the basic cast instrument housing gives benefit in terms of output stability and long electronic component life. With the increased ease of convective cooling, the lamp may be made larger and allowed to operate at higher envelope temperatures.

The lamp housing is connected to the autocollimator optical system by means of an incoherent fiber optic bundle, which accomplishes excellent integration of the source stop illumination. This integration makes the system insensitive to lamp alignment and allows the lamp filament to move with thermal deflection or gravity loading. Also it allows the lamp to be replaced in the field without a tedious realignment procedure. The fiber optic bundle also may be replaced in the field without any adjustment or alignment.

Long-term stability of the electrical null is particularly important in order to maintain the basic angle reference. The stability has been enhanced by using selected integrated circuits with low temperature drift, metal film resistors with low temperature coefficients, as well as zener-regulated power supplies to drive the operational amplifiers. Redesign of the demodulator circuitry to employ solid-state switches, instead of electro-mechanical units, will further enhance the reliability and temperature stability of the instrument.

Resolution has been improved by removing or modifying sources of noise in the optical train. In the new design the resolution has been improved from greater than one

arc second to less than one-half arc second. The secondary source stop consists of a 0.94-millimeter square aperture and means of evenly illuminating the aperture. In the previous design the aperture was produced photographically on a glass plate, but this suffers from internal reflections between the surfaces of the relatively thick plate, which detracts from aperture uniformity. The stop used in the new instrument is a physical aperture, photochemically etched in a very thin metal plate. The photo-detector assembly stop is now made in the same configuration, and is physically against the face of the detector, avoiding problems of spurious light leaking between source and detector. This arrangement also has excellent mechanical stability.

The beamsplitter which divides the incoming and outgoing legs of the optical train was, in the previous design, a solid prism. The prism beamsplitter was found to introduce secondary reflections which prevented a uniform wavefront, thereby increasing optical noise. Tests of intensity distribution across the light beam were run with and without the prism in the path. The distribution was also found to be sensitive to prism alignment.

To reduce optical noise in the new design, a thin Mylar membrane commonly known as a pellicle will be used, instead, as the normal mode beamsplitter. The pellicle, being only on the order of 0.0025 millimeter thick, is essentially free of ghost reflections attendant on a plate or prism beamsplitter.

Also, to reduce noise, great care has been taken to minimize internal reflections within the autocollimator, both by internal baffling and by the application of nonreflective coatings to all surfaces adjacent to the optical path. The objective lens design is unchanged, but it is now narrow band coated with magnesium-fluoride for maximum transmission efficiency at 900 nanometers.

The changes brought about in the new generation of instruments should improve the stability, reliability, and accuracy of the Angle Data System.

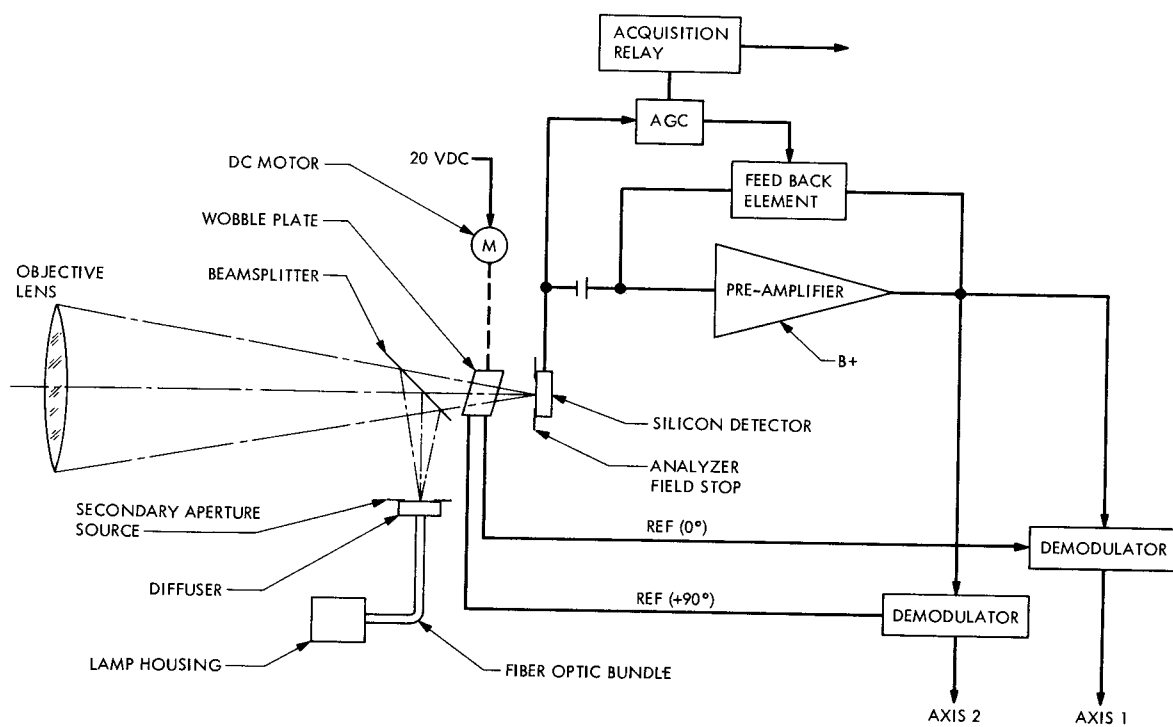


Fig. 1. Two-axis autocollimator block diagram